Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

A99.9
F764UN

United States
Department of
Agriculture

Forest Service

**Intermountain
Forest and Range
Experiment Station
Ogden, UT 84401**

Research Note
INT-322

October 1982

Thinning and Pruning Western White Pine: A Potential for Reducing Mortality Due to Blister Rust

U.S. DEPARTMENT OF AGRICULTURE
NAT'L AGRIC. LIBRARY
RECEIVED
MAY 23 '83
PROCUREMENT SECTION
CURRENT SERIAL RECORDS

**Roger D. Hungerford,[1]
Ralph E. Williams,[2] and
Michael A. Marsden[3]**

ABSTRACT

*Thinning and pruning were tested as potential methods for reducing mortality of western white pine (*Pinus monticola*) infected by the blister rust disease caused by* Cronartium ribicola. *Five years after treatment thinning had increased the number of new lethal infections per tree. Pruning counteracted the effects of thinning.*

KEYWORDS: *Pinus monticola, Cronartium ribicola,* pruning, thinning, disease control

[1]Research forester with the wood resource utilization project at the Forestry Sciences Laboratory, Missoula, Mont.

[2]Supervisory plant pathologist with forest pest management at the Boise field office of the Intermountain Region, USDA Forest Service.

[3]Statistician, USDA Forest Service, State and Private Forestry, Methods Application Group, Fort Collins, Colo.; formerly, mathematical statistician with the fire effects and use project at the Northern Forest Fire Laboratory, Missoula, Mont.

**Approved for publication by Intermountain Station
May 1981**

INTRODUCTION

Cronartium ribicola Fischer ex. Rabenh., the cause of blister rust disease in white pines, has created a serious mortality problem in many areas of North America where native white pines are the most productive timber species. Direct control methods, such as chemical treatments or eradicating *Ribes* spp., the alternate host, appear to be ineffective and/or uneconomical in the West; so in 1968, management of western white pine on National Forests in the Northern Region was temporarily suspended (Ketcham and others 1968).

During the late 1960's, a breeding program begun by the Forest Service in 1950 was yielding favorable results. Effective resistance and a large number of resistance mechanisms were indicated by Bingham and others (1971). Other management strategies to reduce rust-caused losses were also evaluated to provide alternatives and to integrate these with resistant stock (McDonald 1979).

Cultural operations, such as thinning and pruning, are among those alternatives. Although these are commonly used silvicultural practices in the western white pine region, their effectiveness in rust-hazard reduction has not been demonstrated. Stillinger (1947) reported on one pruning study on the Clearwater National Forest. The results were premature and the study inconclusive. Studies on eastern white pine (*Pinus strobus* L.) (Stewart 1957; Stewart and Ritter 1962; Weber 1964) and sugar pine (*Pinus lambertiana* Dougl.) (Hayes and Stein 1957) indicated that pruning was effective for reducing losses due to blister rust. No data have been published on the influence of thinning on blister rust development.

A considerable body of knowledge exists about the basic biology of blister rust and its expression under natural conditions. Stillinger's (1947) data and observations from our studies (unpublished data)[4] indicate that nearly 75 percent of the "lethal" infections (those expected to eventually kill at tree) occur in the lower one-third of a tree. These data represent samples from a wide range of sites and tree ages to 60 years of age.

Spore dispersal in relation to air currents has been studied minimally in western white pine stands (Lloyd 1959). VanArsdel (1961) documented spore dispersal patterns and subsequent infection patterns with eastern white pine in the Lake States. These studies suggested that the microenvironments suitable for infection are more favorable near the ground. Stillinger's (1947) data and our observations (unpublished data)[5] do not reveal changes in height distribution of infections associated with high infection years.

Tree growth rate does not appear to influence growth of branch infections toward the bole, but does seem to influence the proportion of cankers that are lethal (unpublished data).[6] Faster growing trees have fewer lethal infections (infections that will eventually kill the tree). White pine, such as open grown trees, with faster growth exhibit growth segments of greater length than trees in dense stands (unpublished data).[7] On the average, these branch segments are incapable of supporting continuous canker growth; so a greater proportion of the infections are nonlethal. Criteria for judging lethality by length and diameter of branch segments are described by Hungerford (1977).

Our objectives in the study described here, initiated in 1969, were to test the hypothesis that pruning and/or thinning of white pine crop trees will reduce the mortality from blister rust. Pruning was expected to eliminate the hazard of existing infections and reduce target area and therefore the probability of new lethal infections. Thinning was expected to increase branch growth and therefore reduce the probability of new infections being lethal. Increased spacing was expected to decrease the target area exposed to favorable conditions for infections.

We will describe the study sites and treatments, then present the preliminary results. These results are based upon examination and analysis of infection intensity 5 years following treatment. While not conclusive, because sufficient time has not elapsed for mortality to occur, the results are indicative of the final outcome.

[4]Study 116, Forest Pathology Research Work Unit, Intermountain Forest and Range Experiment Station, Moscow, Idaho.

[5]Study 91, Forest Pathology Research Work Unit, Intermountain Forest and Range Experiment Station, Moscow, Idaho.

[6]Study 91, Forest Pathology Research Work Unit, Intermountain Forest and Range Experiment Station, Moscow, Idaho.

[7]Study 510, Silviculture Research Work Unit, Intermountain Forest and Range Experiment Station, Moscow, Idaho.

TEST SITES AND TREATMENTS

Five northern Idaho white pine stands between 10 and 20 years of age and at least 20 acres in size were selected for this study. General location of each study area is shown in figure 1. Selected stands were ecologically classified as being of the *Tsuga heterophylla-Pachistima myrsinites* or *Thuja plicata-Pachistima myrsinites* habitat types (Daubenmire and Daubenmire 1968). In most stands, *Pinus monticola* Dougl. was the dominant conifer species, with lesser amounts of *Abies grandis* Dougl. Lindl. (grand fir), *Pseudotsuga menziesii* (Mirb.) Franco (Douglas-fir), *Tsuga heterophylla* (Raf.) Sarg. (western hemlock), *Picea engelmannii* Parry ex Engelm. (Engelmann spruce), *Larix occidentalis* Nutt. (western larch), and *Thuja plicata* Donn (western redcedar) being present. Individual trees averaged 1.0 to 2.8 inches (2.5 to 7.1 cm) d.b.h. and 7 to 17 ft (2.1 to 5.2 m) in height. Stocking density varied from 2,000 to 13,000 stems per acre.

In each test area, nine square 1-acre (0.4 ha) plots (three replications of each treatment) were laid out and thinned to a 10- by 10-ft (3- by 3-m) spacing. The remainder of the stand was thinned to a 14- by 14-ft (4.3- by 4.3-m) spacing. In each test area, the nine treated plots and controls were located so they could be divided into three groups based on relative slope position—lower, middle, or upper. Treatments were assigned randomly to plots within a slope group. Three treatments were tested: (1) thinning, (2) thinning plus pruning all crop trees, and (3) thinning plus pruning only the western white pine crop trees. All crop trees were selected by using Northern Region guidelines, except that white pines were not discriminated against unless they had bole infections or had branch infections within 4 inches of the bole (termed "nonprunable" trees). Pruning treatments were superimposed onto the thinning treatments. Pruning consisted of removing both live and dead branches from the lower one-third of the tree height and removal of all obviously infected branches that could be reached in the remaining crown. Branches were pruned flush with the bole with handtools or small chain saws. Control plots were located on adjacent unthinned portions of the stand, and crop trees were selected as they were on thinned plots. Neither thinning nor pruning was conducted in the control plots.

Within each plot, a central 1/4-acre (0.1-ha) area was established as the sample area for tree measurements. Immediately prior to treatment, we measured diameters at 4.5 ft (1.3 m), tree heights, and live crown lengths (that portion of the main stem with live branches) for all trees within the quarter acres. The white pines were examined for rust infections. Each infection was identified by its age and its location on the tree, and each was judged as to its lethal or nonlethal potential (Hungerford 1977). This report examines the data collected before treatment and 5 years following the treatments.

Data were subjected to analysis of variance, with observations adjusted for total and lethal canker

Figure 1.—Location of study sites within the Inland Empire sites are marked with a star.

numbers, tree diameter, and tree height before treatment. Additionally, data were transformed ($Y_i = \ln (X_i + 0.5)$, where X_i is the number of infections on the ith tree) to minimize the dependence in data on the variance and mean from a sample. Each study area was considered as a separate analysis because variances among areas were not homogeneous. Tests were for a significance level of $P \leq 0.05$.

RESULTS

Except for the Greenhood area, slope position did not affect infection rate. In all areas the thinned-only treatment resulted in significantly greater numbers of new lethal infections per tree than in the pruning treatments (table 1). The number of new lethal infections per tree were similar for both of the pruning treatments and the controls. Except for Potter Creek and Two Cut Draw, significantly more new lethal infections were found in the thinned-only treatments than in the controls. Except in Johnson Draw, numbers of lethal infections per tree on the pruned treatments were low. For both pruned treatments 66 to 100 percent of the infections were lethal, while for thinned-only and control plots (with the exception of Potter Creek) 30 to 60 percent of the infections were lethal.

It is important to note that treatment effects on new lethal infections are similar over test areas with either high (Johnson Draw) or low (Potter Creek) numbers of infections. Thinning increases the number of new lethal infections per tree over the other two treatments relative to infection level for the site. Pruning resulted in infection rates 50 to 80 percent less than thinning only, but not different from the controls. Another indicator of treatment effectiveness is how many trees are free of infections. We found that fewer trees on the thinned-only treatments were free of lethal infections than on either of the other treatments after 5 years (table 2). Pruned and thinned plots had nearly as many or more trees free of lethal infections than the control plots after 5 years. In addition, more trees on the pruned plots could be effectively pruned again to remove new lethal infections than on either of the other treatments.

When all infections are considered in the analysis (lethal and nonlethal branch infections), we found the pruned treatment had significantly fewer new infections than either of the other treatments (table 3). With this expanded number of infections, the thinning treatment was not significantly different from the controls. As with the lethal infections, the pruned treatments had more trees free of infections than either of the other treatments (table 2).

Table 1.—Average numbers of new lethal infections per tree by treatment for each area 5 years after treatment. Treatments with different lower case letters are significantly different at P = ≤ 0.05. Statistical tests were performed on adjusted, transformed values

Area	Numbers of lethal infections prior to treatment[1]	New lethal infections since treatment[1] — Treatment: White pine pruned	All pruned	Thinned only	No treatment
Johnson Draw	0.9	6.9(a)	5.8(a)	10.9(b)	5.0(a)
Greenhood	.2	1.6(a)	3.2(b)	6.0(c)	1.7(a)
Blickensderfer	.2	1.2(a)	1.0(a)	2.7(b)	1.1(a)
Two Cut Draw	1.0	1.5(a)	1.6(a)	3.6(b)	1.6(a,b)
Potter Creek	.4	.5(a)	.4(a)	1.5(b)	1.2(b)

[1]Average per tree.

Table 2.—Percent of trees by treatment and area with no new infections and no lethal infections before treatment period (1969) and after 5 years (1974). The percent of trees with lethal cankers not prunable is also shown, along with the number that died after 5 years

Area	Trees with no lethal infections						Trees with no infections						Trees not prunable			Rust killed
	1969			1974			1969			1974			1974			
	P[1]	T[1]	C[1]	P	T	C	P	T	C	P	T	C	P	T	C	
	Percent															No.
Johnson Draw	49	54	51	14	10	19	26	24	38	12	6	10	44	57	55	1
Greenhood	88	87	86	34	11	35	73	73	77	28	9	29	28	50	52	
Blickensderfer	88	94	91	53	24	36	78	88	87	53	12	16	21	55	40	
Two Cut Draw	50	48	65	38	24	41	33	29	45	33	13	23	22	51	33	
Potter Creek	73	77	73	72	46	50	67	72	66	72	43	44	19	36	41	1

[1]P = pruned plots;
T = thinned only plots; and
C = plots having no treatment.

Table 3.—Average numbers of new infections per tree by treatment for each area 5 years after treatment. Treatments with different lower case letters are significantly different at P = ≤ 0.05. Statistical tests were performed on adjusted, transformed values

Area	Numbers of infections prior to treatment[1]	New infections since treatment[1]			
		Treatment			
		White pine pruned	All pruned	Thinned only	No treatment
Johnson Draw	3.6	8.4(a)	6.8(a)	19.3(b)	13.5(b)
Greenhood	.7	2.4(a)	3.4(a)	9.8(b)	3.6(a,b)
Blickensderfer	.3	1.3(a)	1.0(a)	6.2(b)	3.6(b)
Two Cut Draw	2.4	1.7(a)	2.2(a)	6.2(b)	3.2(b)
Potter Creek	.6	.5(a)	.4(a)	1.6(b)	1.7(b)

[1]Average per tree.

DISCUSSION

Thinning a western white pine stand without removing blister rust-infected branches will increase infection frequency and decrease the likelihood of maintaining western white pine as a stand component. Based on the results of thinning these stands in five areas of northern Idaho, we reject the hypothesis that thinning will reduce blister rust hazard to western white pine. It is apparent that microenvironments suitable for infection were not altered. Lethal infections were not reduced, at least during this period, because of thinning-induced tree growth. We cannot explain conclusively the cause of this increase in new lethal infections in response to thinning. It appears likely, however, that more foliage was exposed to spore loads on the thinning treatment. We would expect the number of infections to increase as target area increases. Calculations of target area (based on stand densities, tree size, and thinning specifications) indicate that we increased target area by 100 percent on the thinning treatments. Based on this increase, we would expect to have 100 percent more new lethal infections than on the controls. With the exception of Potter Creek, we observed more than 100 percent increase for all areas (table 1). Opening the stand by thinning may increase branch survival by reducing suppression. This also should increase numbers of new lethal infections.

Pruning of thinned trees of all species or only western white pine crop trees negated the increased numbers of infections per tree resulting from thinning only and, in most cases, resulted in fewer infections than in controls. Based on these results we conditionally accept the hypothesis that pruning reduces rust hazard and subsequent mortality. Where pruning was done on thinning treatments, the data support the hypothesis. Pruned and thinned treatments, however, were not different from untreated areas. Unfortunately, we did not prune trees in unthinned situations which makes it difficult to interpret pruning alone. Pruning in addition to thinning did successfully remove existing infections, reducing probability of mortality. Calculations of target area indicate that pruning reduced target area by 55 percent or more. The data (table 1) show that pruning reduced the number of new lethal infections by from 41 to 67 percent. If pruning alone had been done (no thinning) on our test sites, the exposed surface area would not have been reduced much below the controls. Pruning would only have removed the target area already screened by other branches. According to these projections, the target area and number of new infections would have been the same as for the thinned and pruned treatments.

The period following treatment included at least one extremely favorable year for rust infection. In 1969, the average annual percentage of trees infected over the life of the stands was about 2.9 percent, nearly the same as that reported by Carlson and Toko (1968). During the period 1969 to 1974 this rate increased to nearly 8 percent on the thinned-only and control plots, and increased to 3.4 percent on the pruned areas. While the general infection level was higher in 1974, distribution of lethal infections does not appear to have changed.

Treatment effects were similar on all areas with a similar percent increase or decrease in infection noted. It is questionable, however, that pruning in areas of high infection levels can be effective. Even though the hazard will be reduced on high hazard areas, the probability of saving trees is still remote. Evaluation of these treatments after an additional 5 years will give a much better idea of effectiveness in this regard.

Even though slope effects were not generally significant in our study, a large variation in infection intensity exists between the study sites. This suggests that infection rate does vary widely but our plot layout was not adequate to detect slope effects. Results from Greenhood, where slope position did impact infection, indicated a significant increase in infection at the lower slope. Basins and lower slopes may be high hazard sites.

The variation in infection intensity shown here supports McDonald's (1979) suggestion of differential infection intensities with varying sites. McDonald suggests that the development of a method to assess potential for infection, that is, a hazard rating system, would allow for the propagation of low level resistant white pine on large areas of land with low infection hazard. We also believe that the use of a hazard rating

system would allow for maximum efficiency in applying thinning and pruning for control. Thinning and pruning could be applied to low and perhaps moderate hazard areas, but would not be effective in high hazard areas. It appears that the development of a hazard rating system for blister rust infection will be a key to management of blister rust on western white pine.

SILVICULTURAL AND ECONOMIC ASPECTS

Where disease is not a consideration, thinning in 50-year-old white pine stands increases diameter growth, but not height growth (Foiles 1956b). Volume production and diameter growth are maximized for 20-year-old stands at a 10 by 10 spacing (Marvin W. Foiles, personal communication). Pruning up to one-third of the live crown may slightly depress diameter growth for a short period (Helmers 1946). Thinning in conjunction with pruning, however, offsets any depressing effect (Smith 1954). Pruning improves lumber grade (Fedkiw and others 1960; Horton 1966) by producing high quality knot-free lumber (Funk 1961; Henman 1963). Several reports (Fedkiw and others 1960; Shaw and Staebler 1950, 1952; Huey 1950) indicate that pruning can be a good investment. Since clear timber will stay in demand, the financial picture should remain favorable. Several studies report the results of pruning methods, times, and costs (Lemmien and Rudolph 1963; Horton 1966; Foiles 1956a).

RECOMMENDATIONS

At this time, we do not recommend general thinning in white pine stands of the Northern Region. Rather, until a hazard rating system is developed and we have further evaluated treatment effects, we suggest that timber stand improvement efforts with western white pine be confined to stands with obviously low infection levels. Additionally, we suggest that where thinning is to be done, white pine crop trees with the fewest infections (and more importantly, without lethal nonprunable infections) have the lower third of the crown pruned. This will take advantage of naturally produced resistance (Hoff and others 1976) and reduce potential mortality. In addition, economic benefits resulting from producing higher quality lumber can be realized.

Thinning and pruning should be accomplished as late in the development of the stand as possible to allow for maximum selection pressure on white pine while allowing for maximum growth acceleration. This will vary by areas, but approximately 25 to 30 years of age would be best.

Utilization of these techniques will take advantage of reduced infection pressure and low levels of resistance while maintaining maximum adaptability (diversity) in the host population (Hoff and others 1976; McDonald 1979).

PUBLICATIONS CITED

Bingham, R. I.; Hoff, R. J.; McDonald, G. I. Disease resistance in forest trees. Annu. Rev. Phytopathol. 9: 433-452; 1971.

Carlson, C. E.; Toko, H. V. Preliminary report on white pine blister rust incidence survey—1966 and 1967. Missoula, MT: U.S. Department of Agriculture, Forest Service, Region 1, Division of State and Private Forestry; 1968. 3 p.

Daubenmire, R.; Daubenmire, Jean B. Forest vegetation of eastern Washington and northern Idaho. Tech. Bull. 60. Pullman, WA: Washington Agricultural Experiment Station; 1968. 104 p.

Fedkiw, John; Hopkins, Frederick S., Jr.; Stout, Neil J. Economic aspects of growing high quality pine through pruning. Northeast. Logger 8(10): 16-19, 22-23. 39; 1960.

Foiles, Marvin W. Time required to prune crop trees in the western white pine type. Res. Note INT-32. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1956a.

Foiles, Marvin W. Effects of thinning a 55-year-old western white pine stand. J. For. 54: 130-132; 1956b.

Funk, David T. Pruning white pine. A literature review. Tech. Pap. 185. Columbus, OH: U.S. Department of Agriculture, Forest Service, Central States Forest Experiment Station; 1961. 13 p.

Hayes, G. L.; Stein, W. I. Eliminating blister rust cankers from sugar pine by pruning. Res. Note PNW-151. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1961. 8 p.

Helmers, Austin E. Effect of pruning on growth of western white pine. J. For. 44: 673-676; 1946.

Henman, D. W. Pruning conifers for the production of quality timber. Bull. 35. London: United Kingdom Forestry Commission. 1963. 55 p.

Hoff, R. J.; McDonald, G. I.; Bingham, R. T. Mass selection for blister rust resistance: a method for natural regeneration of western white pine. Res. Note INT-202. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 11 p.

Horton, K. W. Profitability of pruning white pine. For. Chron. 42: 294-305; 1966.

Huey, Ben M. The profit in pruning western white and ponderosa pine. Res. Note NRM-85. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Rocky Mountain Forest and Range Experiment Station; 1950. 6 p.

Hungerford, Roger D. Natural inactivation of blister rust cankers on western white pine. For. Sci. 23(3): 343-350; 1977.

Ketcham, David E.; Wellner, Charles A.; Evans, Samuel S., Jr. Western white pine management programs realigned on northern Rocky Mountain National Forests. J. For. 66: 329-332; 1968.

Lemmien, W. A.; Rudolph, V. J. Time studies of hand and power pruning crop trees in plantations. J. For. 61(6): 430-433; 1963.

Lloyd, Merle G. Microclimate studies. Results to date and their practical application to control problems in Region 1. Natl. Blister Rust Control Meet. Proc.; 1959: 29-36.

McDonald, G. I. Resistance of western white pine to blister rust: a foundation for integrated control. Res. Note INT-252. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1979. 5 p.

Shaw, E. W.; Staebler, G. R. Financial aspects of pruning. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1950. 45 p.

Shaw, Elmer W.; Staebler, George R. An analysis of investments in pruning. J. For. 50(11): 819-823; 1952.

Smith, J. H. G. The economics of pruning. For. Chron. 80: 197-214; 1954.

Stewart, D. M. Factors affecting local control of white pine blister rust in Minnesota. J. For. 55: 832-837; 1957.

Stewart, D. M.; Ritter, L. B. A white pine stand seventeen years after control of blister rust. Minn. For. Notes 114; 1962. 2 p.

Stillinger, C. R. Pruning white pine reproduction to salvage a stand heavily infested with white pine blister rust. Serial 138. Washington, DC: U.S. Department of Agriculture, Bureau of Entomology and Plant Quarantine; 1947.

VanArsdel, E. P. The climatic distribution of blister rust on white pine. Stn. Pap. LS-87. St. Paul, MN: U.S. Department of Agriculture, Forest Service, Lake States Forest Experiment Station; 1961. 34 p.

Weber, Ray. Early pruning reduces blister rust mortality in white pine plantations Res. Note LS-38. St. Paul, MN: U.S. Department of Agriculture, Forest Service, Lake States Forest Experiment Station; 1964. 2 p.

The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

Field programs and research work units of the Station are maintained in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with the University of Montana)

Moscow, Idaho (in cooperation with the University of idaho)

Provo, Utah (in cooperation with Brigham Young University)

Reno, Nevada (in cooperation with the University of Nevada)

☆U.S. GOVERNMENT PRINTING OFFICE: 1982-0-576-026/21